Knotweed Treatment through 2012
Cedar River Municipal Watershed

Annual Report
Libraries, Utilities, and Center Committee
Seattle City Council

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EXECUTIVE SUMMARY

In 2010 Seattle City Council passed an ordinance allowing the treatment of the highly invasive plant knotweed with the herbicide Imazapyr within the Cedar River Municipal Watershed (CRMW). The herbicide is applied using a targeted backpack foliar spray. To date, a total of 20.36 acres of knotweed has been found and mapped in the CRMW. Of this, 4.5 acres of small patches have been treated by covering with geotextile fabric. This treatment appears successful only on the smallest patches. Extensive re-growth was seen on slightly larger patches when fabric was removed, even after six years of continual covering. The remaining 15.86 acres is comprised of large patches that have been treated with herbicide from 2010 through 2012. A total of 7.72 acres has been treated with Imazapyr three times (2010-2012), 7.86 acres has had two treatments (2011 and 2012), and 0.28 acres has received only one treatment (2012). Of the 15.86 acres treated with herbicide, only 2.13 acres were located on land that drains into the Cedar River.

After one herbicide treatment, knotweed above-ground biomass was greatly reduced, but mortality was only about 50%, with many plants re-growing throughout all the patches, or small growth buds seen on the plant base. After two herbicide treatments, there was greater mortality, but still significant re-growth that was widely scattered throughout the patches. Amount of mortality after three treatments will not be known until the summer of 2013. SPU works closely with other Washington land managers treating knotweed. The latest data indicate that it may take five to six treatments to achieve >98% mortality in large knotweed patches.

There was no detection of Imazapyr (at a detection limit of 0.02 ug/L, or 0.02 parts per billion) within the municipal drinking water from the Cedar River system after any of the treatments. There is a small creek that does not flow into the Cedar River system that had treated knotweed on both sides and within the creek, plus had some treated knotweed stems floating in the stream. This small creek goes surface-dry downstream of the knotweed for much of the summer. There was an extremely low level of Imazapyr (0.12 ug/L) detected in this creek after Imazapyr treatment in both 2011 and 2012. This level is approximately 14,000,000 times lower than an Imazapyr dose that has been shown to have no adverse effects on a child. The Imazapyr had a half-life in the creek of approximately five days, degrading to undetectable levels within 27 days.

The cost per acre to treat 4.5 acres of knotweed by covering with fabric from 2004 through 2012 was approximately $44,000, and has had very limited success. Cost per acre to treat 15.86 acres of knotweed with herbicide from 2010 through 2012 was approximately $4,800. It appears that eradication will be achievable using herbicide if the effort is continued at a low level.

The 2010 ordinance allowing Seattle Public Utilities to treat knotweed with Imazapyr within the municipal watershed expires on December 31, 2012. If a new ordinance allowing further herbicide treatment is not passed, then the 8.14 acres that have received only one or two treatments will likely revert to extensive knotweed and no further control or restoration will be attempted on these sites, as there are no other viable treatment options. These patches will continue to expand, and may serve as a source for other infestations. The amount of future re-growth on the 7.72 acres that have received three herbicide treatments will not be known until

summer of 2013. If there is little re-growth, it will be controlled by covering with fabric and these sites will subsequently be restored to native plant communities.

BACKGROUND

This purpose of this report is to provide a summary of Bohemian knotweed (*Polygonum* x *bohemicum, P. cuspidatum*, and *P. sachalinense)* treatment within the Cedar River Municipal Watershed (CRMW). It includes location and amount of knotweed present and type of treatment used (both herbicide and non-herbicide), as well as treatment costs and results. It focuses primarily on the herbicide treatment, and includes type of herbicide application, amount of herbicide applied, and water quality monitoring test results. Finally it provides a summary of monitoring results and work planned for 2013 and beyond.

Bohemian knotweed, a hybrid between Japanese (*P. cuspidatum*) and giant knotweed (*P. sachalinense*), is a highly invasive, non-native plant that poses one of the greatest ecological threats of any plant species present in the CRMW. After extensive literature review and consultation with experts (including toxicologists), Seattle Public Utilities (SPU) staff concluded that the risk posed by knotweed was high, viable treatment options were extremely limited, and the risk to water quality posed by treating the knotweed with the herbicide Imazapyr was essentially nil. Seattle City Council agreed with this assessment, and on August 2, 2010 passed Council Bill Number 116902. This ordinance amended the CRMW Secondary Use Policy Number 6-13 to allow limited application of the herbicide Imazapyr to treat knotweed within the municipal watershed. The ordinance is only effective through December 31, 2012 after which the Secondary Use Policy prohibiting all herbicide use within the CRMW will again apply.

In 2013 the King County Noxious Weed Control Board began requiring control of knotweed along the Cedar River. This means that all property owners along the Cedar River (including SPU) are required to control knotweed within about 165 of the ordinary high water mark.

In 2008 the total area infested with knotweed within the municipal watershed was measured at 15 acres. Of this, small scattered patches totaling 4.5 acres were experimentally treated by covering with geotextile fabric, a tough polypropylene fiber product often used in road construction. Covering knotweed with fabric is a difficult and expensive process by which we attempted to starve the roots by not allowing any light to reach the plant. The fabric must be actively checked and maintained multiple times per year (wildlife often tear it up, wind will dislodge it, plants will grow through it, etc). Staff started covering small knotweed patches in 2004 and continued covering various small patches through 2009, when fabric installation was completed. In 2010 and 2011 we experimentally removed some of the fabric after five or six years of continual covering. The plants appear to have died within the smallest patches. On slightly larger patches, however, there was extensive re-growth even after six years of continual covering. It is unknown whether this covering treatment will eventually be successful in eradicating these knotweed patches, but results do not appear promising on larger patches.

The remaining 10.5 acres of knotweed (as measured in 2008) were in patches too large to logistically cover and maintain with fabric. We started treating these patches with Imazapyr in 2010 after passage of the ordinance. Approximately half of the large patches were treated for the first time in 2010. The remaining known patches were treated for the first time in 2011.

This knotweed project is part of the Major Watersheds Invasive Species Program, with operations and maintenance funding provided through the SPU Water Fund. This Program,

funded since 2007, encompasses the CRMW, the Tolt Municipal Watershed, and the Lake Youngs Reserve (total of more than 100,000 acres). There are 61 terrestrial and two aquatic non-native invasive plant species present in the watersheds, 11 of which are legally required to eradicate or control. The Invasive Species Program controls all 11 legally required species, plus nine other species that either pose a very high ecological risk, or pose a significant ecological risk but are not yet widespread. Ten additional species that pose significant ecological risk but are already widespread are controlled in limited areas where they occur in sensitive habitats. Knotweed is not currently legally required to control in the watersheds, but poses one of the greatest ecological risks of any of the invasive species. One Invasive Species Program goal is to eradicate all knotweed from the CRMW. Invasive Species Program funding through 2012 was sufficient to cover all knotweed treatment and monitoring.

HERBICIDE APPLICATION METHOD

In all three years (2010-2012) we used a targeted, backpack foliar spray of 1% Imazapyr mixed with a 1% modified vegetable oil surfactant in water. Because Imazapyr is a clear liquid, a small amount of non-toxic blue dye was added to this solution to allow us to see what portions of the plants had been sprayed. All applications were done during calm, dry weather when there was no atmospheric inversion (which can increase the risk of drift onto non-target plants). The backpack foliar spray method proved very effective at focusing the spray on the knotweed foliage and produced little or no overspray or drift onto adjacent plants. Neither native nor non-native plants immediately adjacent to knotweed plants were damaged by the application. As expected, the knotweed plants showed no immediate effects from the spray, because Imazapyr works slowly over time within the plant, inhibiting an enzyme found only in plants.

We used the foliar spray method rather than the stem injection method because recent research has found that stem injection 1) uses over five times more herbicide, 2) does not produce any higher knotweed mortality, and 3) is not significantly better at minimizing damage to adjacent plants than foliar spray. We chose to use Imazapyr because it is the least toxic herbicide available, less toxic than Glyphosate (the herbicide found in Roundup, available for purchase by the general public). Currently Glyphosate is the only herbicide legally allowed to be used with the stem injection method.

SAFETY

At least one Washington State certified herbicide applicator was on site during all knotweed spraying activity. Certified applicators mixed all herbicide backpack tank solutions and supervised all aspects of the application process. Both an Operational Plan and Safety Plan were developed and successfully implemented during the treatments. There were no spills, and no injuries or adverse effects were incurred by SPU staff or the contract crew members conducting the herbicide applications. Trails adjacent to the knotweed patches were closed to the public during the applications. Permanent interpretive signs were placed at strategic locations near the Education Center knotweed patches to inform the public about the project, and temporary herbicide application signs were placed adjacent to all sprayed patches accessible by the public, as legally required.

AMOUNT OF LAND TREATED WITH HERBICIDE

A total of 7.72 acres of knotweed received the first herbicide treatment in 2010. These patches were located at the Cedar Falls Compound, the Education Center & Rattlesnake Lake, Masonry Dam, and isolated border patches near the southern and western municipal watershed boundaries. These same 7.72 acres were treated for the second time in 2011 and third time in 2012 (see areas in red in Figure 1). A total of 7.86 acres were treated for the first time in 2011 and the second time in 2012. (Note: this amount was reported as 7.7 acres in the 2011 Annual Report due to an error in the Geographic Information System layer, now corrected.) These patches were located primarily at and near Taylor Townsite, but also include two patches newly found in 2011, one near the Masonry Dam and the other near Rattlesnake Lake (see areas in orange in Figure 1). This brought the total area treated with herbicide in 2011 to 15.58 acres. In 2012 two new patches totaling 0.27 acres, one inside and one outside the hydrographic boundary, were found and treated for the first time. One patch was near the Masonry Dam and one was near Rattlesnake Lake (see areas in purple in Figure 1). In addition, one patch (0.01 acres) at Taylor Townsite was missed in 2011 and treated for the first time in 2012. Total area treated with herbicide in 2012 was 15.86 acres.

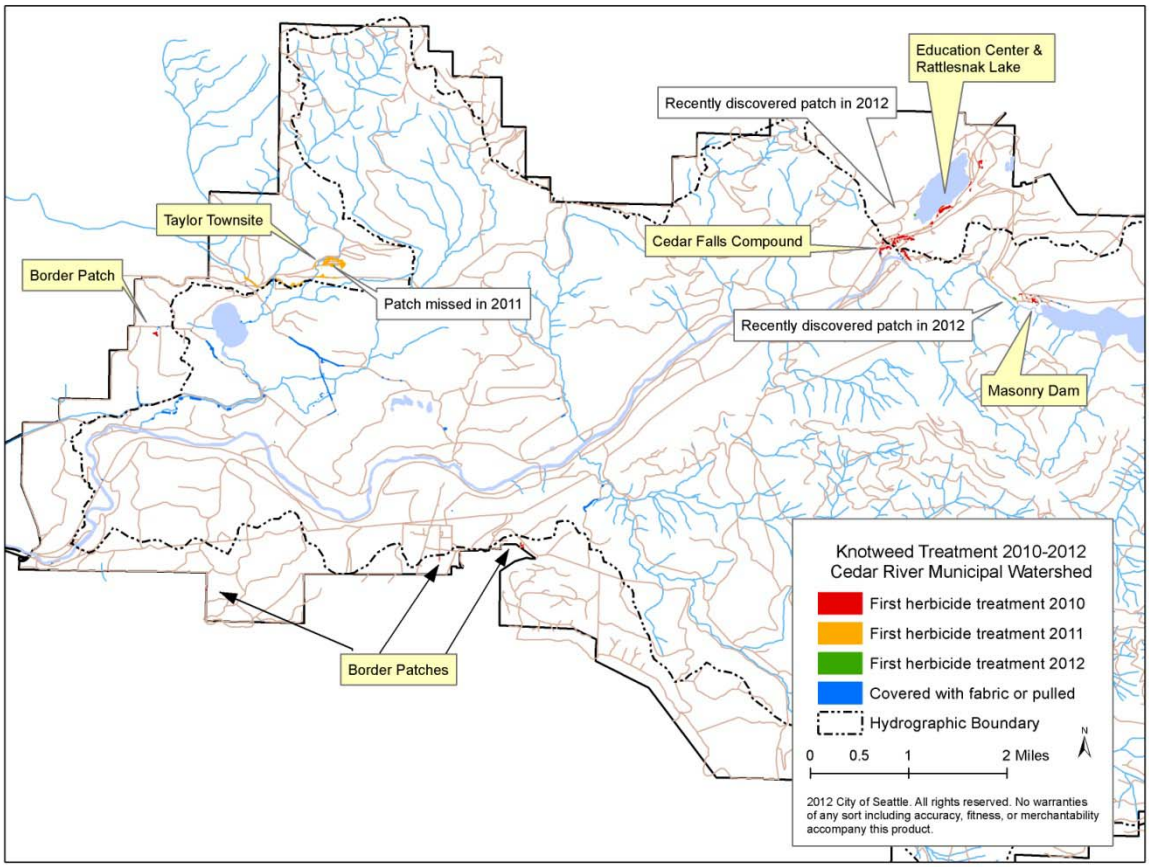

Figure 1. Location of knotweed patches treated with herbicide in 2010, 2011, and 2012. Areas in red were treated for the first time in 2010, the second time in 2011, and the third time in 2012. Areas in orange were treated for the first time in 2011 and the second time in 2012. Areas in green were treated for the first time in 2012. The Cedar River hydrographic boundary is shown as a dashed black line and the ownership boundary is shown as a solid black line.

Total area treated with herbicide in 2012 exceeded by 5.36 acres the 10.5 acres originally estimated in 2008 to be infested with large patches of knotweed. Newly discovered patches accounted for 0.4 acres of this increase. The remaining 4.96 acres resulted from more accurate mapping technology and rapid patch expansion, one illustration of the extreme ecological threat posed by knotweed.

Of the 15.86 acres of knotweed treated with Imazapyr in 2012, only 2.13 acres were located within the hydrographic boundary of the Cedar River, i.e., occupying land that drains into the Cedar River. The remaining 13.73 acres were on land draining to other rivers, primarily the Snoqualmie River and Issaquah Creek (see Table 1). No herbicide-treated knotweed patch was closer than 250 feet to the Cedar River or any of its tributaries, and there was forested land between the patch and the river. Of the treated knotweed patches within the hydrographic boundary, the one nearest to the Landsburg municipal water intake was more than 12 river miles away.

Table 1. Number of knotweed-infested acres treated with Imazapyr by site and year.

Cedar River Hydrographic Boundary	Site	Number acres	Treated in 2010	Treated in 2011	Treated in 2012	Total Number Treatments through 2012
Inside	Masonry Dam	0.31	X	X	X	3
		0.08*		X	X	2
		0.19**			X	1
	Cedar Falls	1.55	X	X	X	3
	Total Inside	**2.13**				
Outside	Cedar Falls	1.71	X	X	X	3
		0.04*		X	X	2
	Education Center/ Rattlesnake Lake	3.04	X	X	X	3
		0.06*		X	X	2
		0.08**			X	1
	Border	1.11	X	X	X	3
		0.02*		X	X	2
	Taylor	7.66		X	X	2
		0.01**			X	1
	Total Outside	**13.73**				

* Patches missed during the first application in 2010 or newly found in 2011
** Patches missed during the first application in 2011 or newly found in 2012

In summary, a total of 7.72 acres have received three treatments, 7.86 acres have received two treatments, and 0.28 acres have received a single treatment.

PRE-TREATMENT

Most of the knotweed patches scheduled for a first herbicide application were pre-treated by bending canes four to six weeks prior to the herbicide application. This pre-treatment worked very well, allowing access through the dense mass of canes and ensuring the applicators could

safely and efficiently spray all portions of the plants. In 2010 canes were bent in late July, with spraying commencing in late August and extending through mid-September. There was a variable and generally moderate amount of knotweed re-growth during this time, depending on the site. September of 2010 was extremely wet, making the logistics of obtaining contract crew time to spray only on dry days difficult. Consequently, in 2011 canes at Taylor Townsite were bent in early to mid-June so we could spray in early August, generally the driest month of the year. Spraying in 2011 started the first of August and was basically completed by the end of August. There was an extremely large amount of re-growth of the pre-treated patches in 2011, likely due to the very wet June and July and the longer time between bending canes and the herbicide treatment.

No cane bending was required for the second application because the first herbicide treatment resulted in a much lower density of canes that were much shorter during the subsequent year. However, the large mass of dead canes and other forest debris made it difficult for applicators to examine the bases of the knotweed plants for any growth. So in 2012, all sites were pre-treated by clearing the dead debris from the site. This allowed the applicators to quickly and easily examine every knotweed plant. Spraying in 2012 took place in early September, which was very dry, making the application quite efficient.

IMAZAPYR TREATMENT RESULTS

In the spring of 2011, there was an approximate 90% above-ground biomass reduction in the knotweed patches treated for the first time in 2010 (compare Figure 2, before any treatment, with Figure 3 taken in spring one year after the initial treatment). As expected, during the summer of 2011, smaller more isolated canes grew scattered throughout the treated patches. Figure 4 shows growth by early summer and Figure 5 shows the typical amount of growth in late summer, one year after the initial treatment. The amount of re-growth one year after the first treatment was generally one to three feet in height with most plants fairly isolated, rather than a solid mass of 12-foot tall canes.

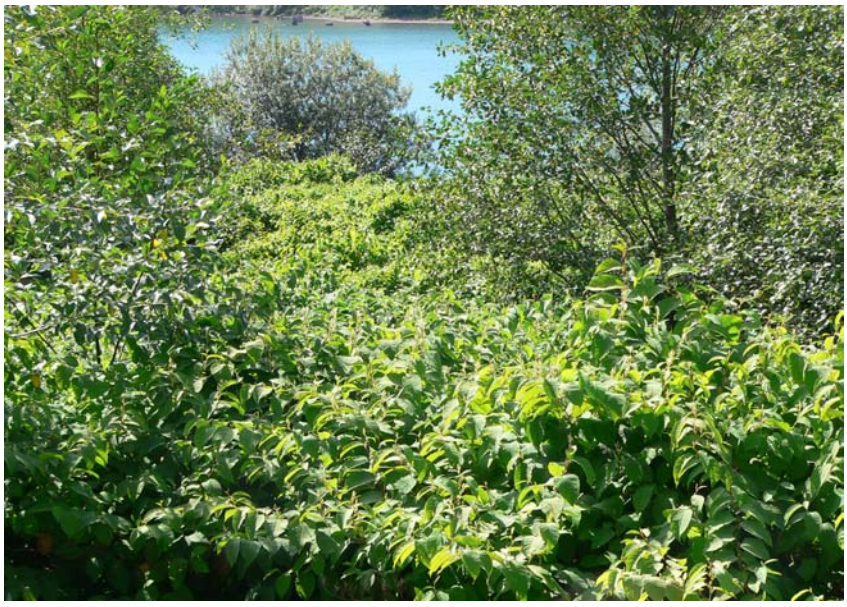

Figure 2. Knotweed near the Education Center before any treatment.

Figure 3. Large knotweed above-ground biomass reduction in early spring after first Imazapyr treatment. The large amount of dead canes made it difficult to see the bases of each plant.

Figure 4. Small, scattered knotweed re-growth seen in early summer 2011, after first Imazapyr treatment.

Figure 5. Moderate knotweed growth, late summer 2011, after first Imazapyr treatment. Canes were sufficiently scattered and short that applicators could easily reach all foliage with the spray. No pre-treatment of bending canes was needed before spraying.

In 2011 when we moved the remnants of dead canes and carefully examined the base of the plants, we unexpectedly found small growth nodules on over 50% of the plants treated for the first time in 2010 (Figure 6). These nodules were often seen on plants that had no other visible growth. So although we achieved a high above-ground biomass reduction with a single treatment, the individual plant mortality rate after one treatment was relatively low, around 50%. This may be due to the relatively low application rate of 43 ounces of Imazapyr per acre in 2010 (see following section), or may be typical but not normally observed because most land managers do not have to eradicate knotweed in such a short time frame and likely do not examine the plant bases. In 2011, we had the herbicide applicators examine the base of every plant that had been treated in 2010 and spray these small growth nodules, if present, as well as spray all green stems or leaves.

In 2012, patches that had received two prior treatments (Cedar Falls Compound, Education Center & Rattlesnake Lake, Masonry Dam, and border patches treated in 2010 and 2011) had far fewer and shorter plants than were seen in 2011. See Figures 7 and 8 for examples of the amount of re-growth seen in 2012 on sites that had received two treatments. While re-growth was greatly reduced, it was still widespread throughout the patches and required a third application of herbicide. Spraying the small growth nodules in 2011 did appear to be effective, as the vast majority of plants that had two treatments did not have these growth nodules present. The small nodules were present on some plants at Taylor Townsite, one year after the first treatment, but in fewer numbers than were observed in 2011 after the initial treatment in 2010. The higher initial dose used at Taylor Townsite (see following section) likely produced this higher mortality.

Figure 6. Small growth nodules at the base of knotweed plants, late summer 2011, after first Imazapyr treatment.

Figure 7. Scattered knotweed re-growth in the Cedar Falls Compound, seen in late summer of 2012 after two Imazapyr applications (in 2010 and 2011).

Figure 8. Scattered knotweed re-growth near the Education Center, seen in late summer of 2012 after two Imazapyr applications (in 2010 and 2011).

After each treatment (2010-2012), we surveyed the patches for any animal mortality resulting from the herbicide application. No animal mortality was seen in any of the knotweed patches during these surveys.

AMOUNT OF IMAZAPYR APPLIED

The Imazapyr label recommends using an amount of 48 to 64 ounces of Imazapyr per acre of knotweed. The maximum legal allowable dose is 96 ounces per acre per year. The amount of herbicide actually applied is dependent on the amount of plant surface available for treatment. In 2010 we averaged 43 ounces of Imazapyr per acre for the first treatment of the patches at the Cedar Falls Compound, Education Center & Rattlesnake Lake, Masonry Dam, and the border patches. This was below the recommended rate because we had less re-growth than anticipated after the cane-bending pre-treatment, likely because of the short time interval between pre-treatment and herbicide application and the dry August in 2010.

In 2011 we averaged 64 ounces of Imazapyr per acre of knotweed on those sites treated for the first time at Taylor Townsite. This is at the top of the recommended range, while remaining well below the maximum allowable rate. The reason for the difference in application rate between 2010 and 2011 is that there was much greater re-growth after the cane-bending pre-treatment at Taylor Townsite in 2011, and consequently much greater leaf area to treat.

For those patches receiving the second treatment in 2011 (Cedar Falls Compound, Education Center & Rattlesnake Lake, Masonry Dam, and border patches), we averaged 24 ounces of Imazapyr per acre of knotweed. This lower rate was expected because the first treatment

resulted in fewer and smaller canes with much less leaf area than plants that had not received any herbicide treatment.

In 2012, for those patches receiving the second treatment (primarily Taylor Townsite), we averaged 18 ounces of Imazapyr per acre of knotweed, about 6 ounces per acre less that we used for those patches receiving their second treatment in 2011. This lower second application dose was likely because this area had received a somewhat higher initial dose during 2011 (64 ounces per acre), which may have resulted in initial higher mortality, and thus less re-growth in 2012.

For patches receiving the third treatment in 2012 (Cedar Falls Compound, Education Center, Rattlesnake Lake, Masonry Dam and border patches), we averaged between 9 and 10 ounces of Imazapyr per acre, reflecting the far fewer stems, more isolated plants, and less leaf area as a result of the two previous herbicide treatments.

WATER QUALITY TEST RESULTS

Water samples were taken both before (baseline) and after (post-treatment) the herbicide applications in all three years, in accord with the sampling plan outlined in Attachment A to the ordinance. All water samples were analyzed for Imazapyr at Pacific Agricultural Laboratory (PACLAB) in Portland, Oregon. This laboratory is accredited with the Washington Department of Ecology and was recommended by the SPU Water Quality Laboratory. PACLAB specializes in analysis of all types of pesticides and has an extremely low detection limit for Imazapyr of 0.02 ug/L, or 0.02 parts per billion.

For knotweed patches within the hydrographic boundary, baseline samples were taken prior to herbicide treatment in both the Cedar River (at the point closest to a knotweed patch = 250 feet away from a patch) and at the Landsburg water supply intake facility (over 12 miles downstream from the closest knotweed patch). Post-treatment samples were taken at these same sample locations in the morning following treatment (approximately 16 to 20 hours post-treatment). Water samples were taken from Rattlesnake Lake (outside the hydrographic boundary) prior to treatment of patches at the Education Center and Rattlesnake Lake, and in the morning following treatment of these patches. No Imazapyr was detected in any of these samples in all three years.

At Taylor Townsite there is a small creek (bankfull width less than three feet) that runs along the edge of and through a small portion of the large knotweed patch. It flows into the Taylor Overflow Ditch which eventually reaches Issaquah Creek (i.e., does not flow into the Cedar River). The Taylor Overflow Ditch is surface dry for much of the year and portions of the creek itself are often dry during summer. In the summer of 2011 there was a small amount of water in the creek at the location where knotweed spans both sides of the creek. We took water samples both the day before (baseline) and the morning after the 2011 treatment, sampling at the site where knotweed was growing on both sides of the creek and within the creek bed itself. The water level was low, with very little flow during sampling. Most water had collected in a small pool at the sample site, although there was a small amount of surface flow continuing in the creek at this point. The creek, however, did go surface dry prior to reaching the Taylor Overflow Ditch, which was also surface dry, so there was no surface flow connectivity to Issaquah Creek.

PACLAB unexpectedly found 0.07 ug/L Imazapyr in the 2011 Taylor Townsite baseline sample. The laboratory did extensive testing for cross-contamination and re-ran the sample, finding the same result. The only plausible explanation was that when SPU staff collected the water sample, they stepped into the creek with boots that had been worn when walking through a different, recently treated site. It is likely that a small amount of Imazapyr adhered to the boots, was transferred to the stream during sampling, and was subsequently detected in the test, a definite indication that the laboratory test is extremely sensitive to even very small amounts of Imazapyr.

When the water sample was taken the day after treatment, several large knotweed canes that were treated the previous day had fallen into the creek and were floating in the small pool of water. We realized this would result in a positive reading of Imazapyr, and indeed the laboratory detected an Imazapyr concentration of 0.12 ug/L (=0.00012 mg/L) in the sample. This is an extremely low concentration, many orders of magnitude below levels that have been proven to have no adverse effect on humans or animals. For example, the No Observable Adverse Effect Level (NOAEL) of Imazapyr for a 10-kg human child is 250 mg/kg/day. To be extremely conservative, the Environmental Protection Agency uses a reference dose 100 times lower than the NOAEL, or 2.5 mg/kg/day. A child is assumed to consume 1.5 liters of water per day. If a child consumed 1.5 liters of the water from this creek, that would be a total of 0.00018 mg of Imazapyr, or a dose of 0.000018 mg/kg/day. This is approximately 140,000 times lower than an Imazapyr dose that is 100 times lower than a dose that has no adverse effects on a child.

This result demonstrated that even this worst-case scenario of recently treated canes falling directly into a very small amount of slowly flowing water resulted in only minute concentrations of Imazapyr in the water. We took additional samples from this same location on the creek 15 and 27 days after treatment. The concentration in the sample taken at 15 days post-treatment had decreased to 0.02ug/L, with the Imazapyr degrading in sunlight in water at the expected rate, decreasing by over three half lives (half-life of five days). As expected, there was no detectable Imazapyr in the final 2011 sample.

In 2012 there was a similar situation in the same small creek at the Taylor Townsite, where there were treated knotweed canes growing within and adjacent to a very small amount of slowly flowing water. This year the baseline sample had no detectable Imazapyr, but the sample taken the morning following application again had an Imazapyr concentration of 0.12 ug/L. A sample taken 34 days after treatment had no detectable Imazapyr in this small creek. As in 2011, in 2012 the creek went surface dry further downstream from the sample site.

TREATMENT COSTS

As mentioned in the Background section, covering and maintaining geotextile fabric on knotweed is extremely expensive. From 2004 through 2012, a total of $198,000 was spent to install and maintain plus remove some of the fabric on 4.5 acres, for a total per acre treatment cost of $44,000. This cost includes purchasing the fabric, and labor for regular staff, field technicians, and contractors to install, maintain, and remove the fabric.

To date, the total amount spent to treat 15.86 acres with herbicide from 2010 through 2012 (three treatments on 7.72 acres, two treatments on 7.86 acres, and one treatment on 0.28 acres) was $76,500, for a per acre treatment cost of $4,800. This cost includes purchase of herbicide, staff

and contractor labor for both pre-treatment and herbicide application, and all the water quality testing.

LONG-TERM OUTLOOK

SPU is working closely with researchers and land managers treating knotweed throughout western Washington, annually sharing data, treatment results, and field experiences to ensure that the most current information is being used in their decision making. There is consensus among all these practitioners that herbicide treatment is the only effective technology to eradicate or substantially control large patches of knotweed, and that Imazapyr poses essentially no environmental risk when used according to the label to treat knotweed.

In 2010, when the original ordinance allowing Imazapyr treatment was passed, there was little long-term local data on the response of large knotweed patches to repeated herbicide application. Some early results indicated that three years of treatment might be sufficient to cause significant mortality. However, in the intervening three years, data from throughout western Washington is showing that more than three years of sequential treatment is required to achieve high levels of mortality for most large patches. In fall of 2012, one Washington land manager reported that after five consecutive years of herbicide treatment, their large patches had been reduced by over 98%. Others are starting to see similar results.

Because each location has a unique, site-specific set of environmental conditions, it is impossible to accurately predict exactly how many treatments will be required in each patch to achieve >98% mortality. However, based on current data, we are hopeful that five to six years of treatment should be sufficient to achieve that level of mortality in our patches, after which the amount of re-growth will be small enough that we could then control it using geotextile fabric.

2013 PLANNED WORK

Results from the experiment of long-term covering with fabric demonstrate the extreme difficulty in killing even small patches of this species with this method. Herbicide is clearly effective against this plant, both in terms of amount of plant mortality and cost-effectiveness. However, the amount of re-growth observed a year after the second treatment clearly demonstrates that a minimum of three herbicide treatments is required on each knotweed patch. It may require more than three treatments to achieve eradication, but those site-specific data will not be available until the summer of 2013. As mentioned above, other landowners within Washington State have reported that after five years of treatment they have reduced patches by more than 98%. However, it has also been observed in some areas that even after three years of no observed growth within large knotweed patches, plants can suddenly re-appear. So long-term monitoring is required.

The type of knotweed work required in 2013 is dependent on whether legal permission to continue use of herbicide on knotweed will be granted by Seattle City Council through another ordinance. Approximately eight acres of knotweed (primarily at and near Taylor Townsite) have only had either one or two herbicide treatments. If permission to continue to use herbicide on knotweed in 2013 is not obtained, then no other viable treatment options exist for these large patches. Consequently, these acres will be left to grow back into extensive knotweed patches and no further control and restoration work will be conducted on these sites. If permission to

continue herbicide treatment is obtained, then these areas will be treated for either the second or third time using the same protocols as were used in 2010-2012. We anticipate that the second treatment would require approximately 20 ounces of Imazapyr per acre and third treatment about nine ounces per acre.

All sites that have had three herbicide treatments will be closely monitored in 2013 and any re-growth documented. If only occasional small knotweed growth is found, it will be covered with fabric. However, if there is still widespread growth, indicating that the massive roots of the plants are not yet dead, then if permission to continue to use herbicide is granted, the sites will once more be treated with Imazapyr, likely at a rate of less than five ounces per acre. If an ordinance is not passed and re-growth is widespread, then these sites will also likely be left to continue growing knotweed, as there are no other viable treatment options for large patches.

MONITORING

A key tenant of the Major Watersheds Invasive Species Program is the Early Detection/Rapid Response (EDRR) protocol. This strategy, implemented to varying degrees since 2007 depending on staff availability and funding, involves routine surveys conducted by qualified biologists for a large number of invasive species. This includes surveying for many species already present in the watershed, as well as species that potentially could invade but have not yet been documented. If a new infestation is found, it is rapidly treated while it is still small enough to eradicate in a cost-effective manner and before it has a chance to spread and cause significant ecological damage. This strategy has been proven world-wide to be the most cost-effective way to deal with invasive species.

As part of the EDRR protocol, we conduct annual surveys of high risk areas to find any new knotweed patches that might occur. Surveys of areas at lower risk for invasion are conducted on a routine, but less frequent basis. High risk areas include riparian areas downstream of known patches of infestation and areas within the forest in close proximity to known patches. If new patches are small, they are treated immediately by pulling or covering with geotextile fabric. Through 2012, if we found any large previously undiscovered patches (as we did in both 2011 and 2012) under the ordinance we treated them using the same targeted backpack spray protocol described above.

Once all herbicide treatments are completed, all known knotweed patches in the municipal watershed will be monitored at least twice per year during the growing season to document response to treatment. If any small patches of knotweed re-growth are found, they will be immediately covered with geotextile fabric. Once the fabric is placed, it will be monitored multiple times per year the first year it is placed. Monitoring frequency of fabric patches can slowly decrease over time, eventually down to twice per year. We will experimentally remove the fabric after several years (likely at least five years), and then monitor the patches frequently. If re-growth occurs, the fabric will be again placed on the patch and maintained for several more years.

If no knotweed growth is found, routine monitoring will continue twice a year for a minimum of five years after complete mortality is achieved. After that, monitoring will be on-going but on a less frequent basis.

SITE RESTORATION

We plan to restore all former knotweed patches to native plant communities, both to provide high quality fish and wildlife habitat and to increase resistance to re-invasion by other non-native invasive species. During the routine monitoring described above, notes about natural regeneration of native plant species, as well as invasion by non-native invasive species will be recorded. Non-native invasive species will be removed using hand methods (pulling, grubbing out roots) as funding allows. In order to provide long-term shade that will help make the site less likely to be overrun with invasive species, native conifer trees will be planted along edges of knotweed patches after three years of herbicide treatment. Planting within the knotweed patches will start after three to four years of herbicide treatment, depending on site-specific conditions, such as degree of knotweed mortality and amount of natural regeneration by native species, and as funding allows. If necessary, we will periodically plant additional native species throughout the sites, to ensure that the habitat is restored to a functioning native system.